The National Environmental and Epidemiologic Assessment of Recreational Water:

The relationship between novel indicators of water quality and health

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USEPA Science Forum

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The NEEAR Study Team

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BEACHES Act of 2000 from Congress

1. **Determine microbial indicators for beach water quality**
2. **Develop efficient protocols for monitoring**
3. **Assess human health risks**
4. **Provide guidance to beach managers**

- **Final Goal: New risk-based water quality guidelines & rapid monitoring methods for recreational waters.**

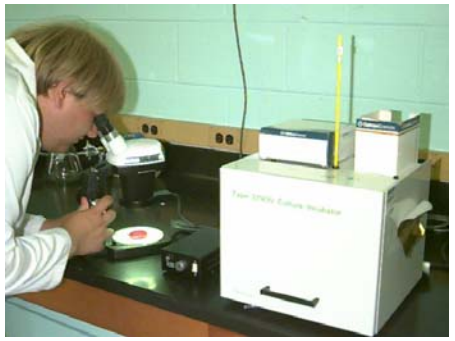
Research Question

Is there an association between illness and recreational water quality as measured by rapid methods of determining water quality?

STUDY APPROACH

Water sampling methods

New rapid detection methods



Health studies

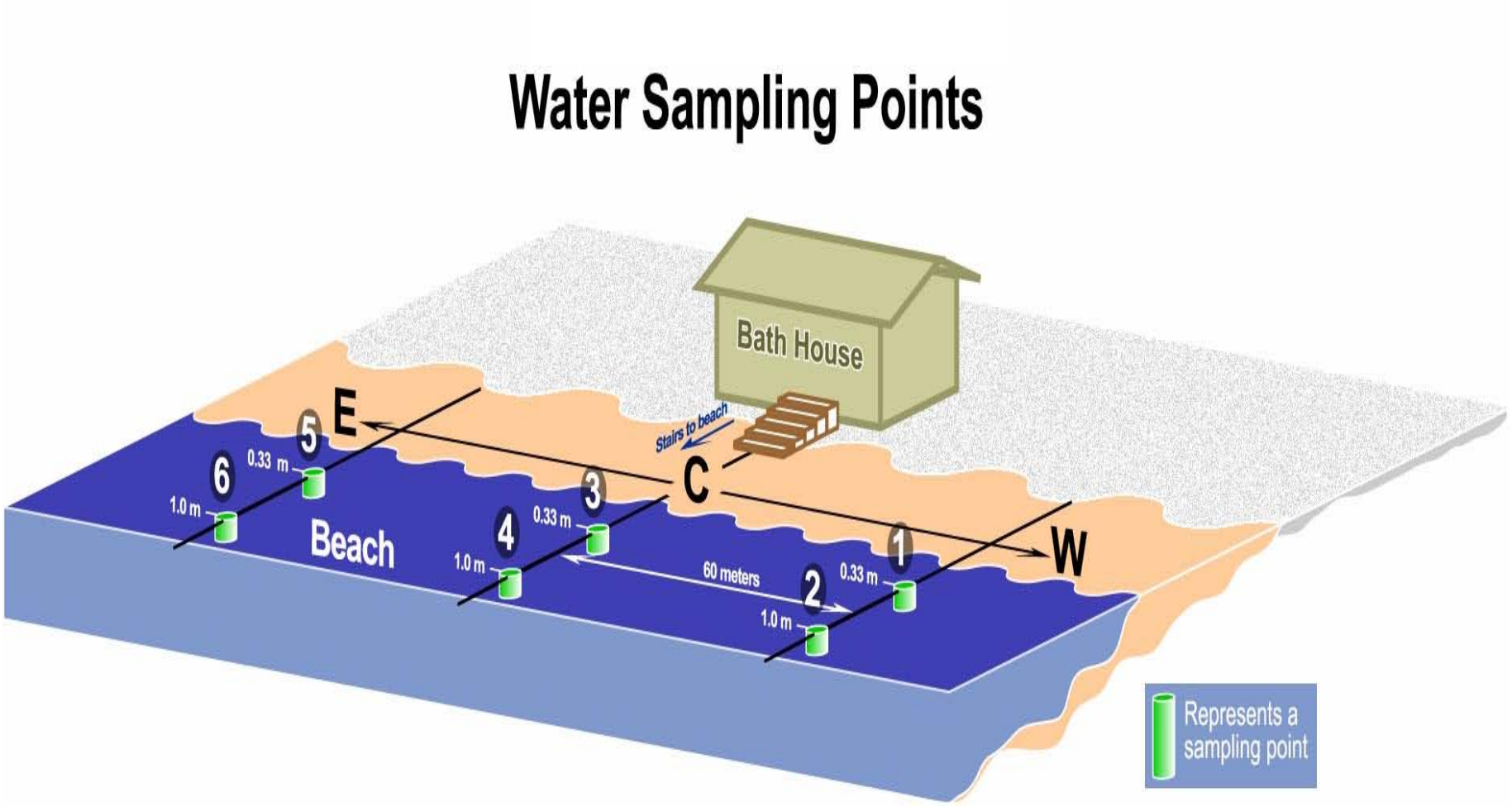
New, rapid, validated water quality indicators (under 2 hours for results)


2003 Beach Sites
Minnesota
Wisconsin
Illinois
Indiana
Ohio
Pennsylvania
New York
Duluth LE
Whittlesey Creek NWR
Huron NWR
Iron River NFH
Ashland FRO
Marquette SLC
Whitefish Point NWR
Pendills Creek
Harbor Island NWR
Seney NWR
Hiawatha Forest NFH
Gravel Island NWR
Michigan Islands NWR
Jordan River NFH
Michigan Islands NWR
Alpena FRO
Green Bay ES
Green Bay FRO
Fox River NWR
Necedah NWR
Horicon NWR
Leopold WMD
Madison LE
Ludington SLC
Bay City LE
Shiawassee NWR
Barrington LE
Grand Rapids LE
East Lansing ES
Ann Arbor LE
Chicago ES
Rosemont LE
Chicago LE
Detroit River International WR
Detroit LE
Cedar Point NWR
Northern Indiana ES
Ottawa NWR
Sandusky LE
Lower Great Lakes FRO
Iroquois NWR
Montezuma NWR
Amherst LE
New York ES
Allegheny NFH
Mercer LE
Northeast Fishery Center
Pennsylvania ES
Ottawa River

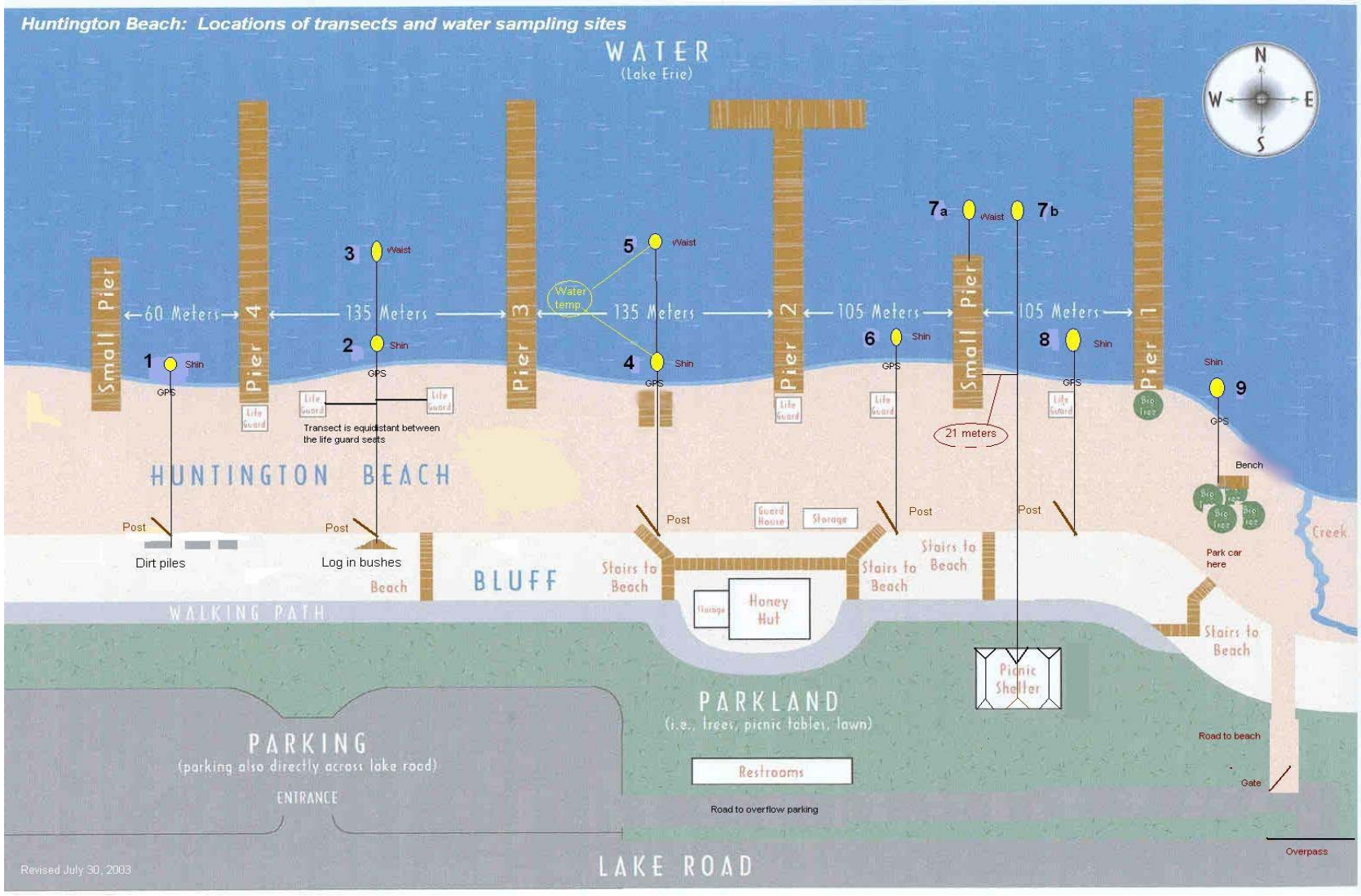
Water Sampling Strategy

- **Taken 3 times daily** → **8:00 AM**, **11:00AM**, **3:00 PM**
- **Two depths** → **.3 meters**, **1.0 meter**
- **Modified sampling scheme according to beach area**

Lake Michigan



Lake Erie


Huntington Beach: Locations of transects and water sampling sites
WATER
(Lake Erie)
N
W
E
S
Small Pier
Pier 4
Pier 3
Pier 2
Small Pier
Pier 1
60 Meters
135 Meters
135 Meters
105 Meters
105 Meters
1 Shin
GPS
2 Shin
GPS
3 Waist
4 Shin
GPS
5 Waist
Water temp
6 Shin
GPS
7a Waist
7b
8 Shin
GPS
Shin 9
GPS
Transect is equidistant between the life guard seats
21 meters
HUNTINGTON BEACH
Post
Dirt piles
Post
Log in bushes
Post
Post
Post
Bench
Park car here
Creek
Beach
BLUFF
Stairs to Beach
Stairs to Beach
Stairs to Beach
Stairs to Beach
Guard House
Storage
Storage
Honey Hut
WALKING PATH
Picnic Shelter
PARKLAND
(i.e., trees, picnic tables, lawn)
PARKING
(parking also directly across lake road)
ENTRANCE
Restrooms
Road to overflow parking
Road to beach
Gate
Overpass
Revised July 30, 2003
LAKE ROAD

Water Quality Measures

- **Enterococci Method 1600**
  - **Current standard**
  - **Colony forming units 24-48 hrs**
  - **Intestinal tract bacteria, warm blooded animals**
- **QPCR: Enterococci and Bacteroides**
  - **Quantitative (real time) polymerase chain reaction**
  - **DNA based technology**
  - **Two hours**
  - **Intestinal tract bacteria**
  - **Bacteroides, 2-3 log higher density, anaerobe, dies in environment**

Exposures and Health Outcomes

- **Exposures:**
  - **Any contact with water (“any contact”)**
  - **Immersed body in water (“body contact”)**
  - **Head under water (“head under”)**
- **Outcomes**
  - **Gastrointestinal illness (GI), skin rash, earache, eye irritations, respiratory illness (URI)**

2003 Data Collection

Lake Michigan

- May 31-August 3
- 20 days of surveying
- 2877 completed interviews
- 67% completion rate

Lake Erie

- July 27-September 14
- 16 days of surveying
- 2840 completed interviews
- 60% completion rate

Lake Michigan Water Quality

- **3 of 20 days (15%) exceeded current standards (33 cfu/100ml)**
- **Enterococci Method 1600**

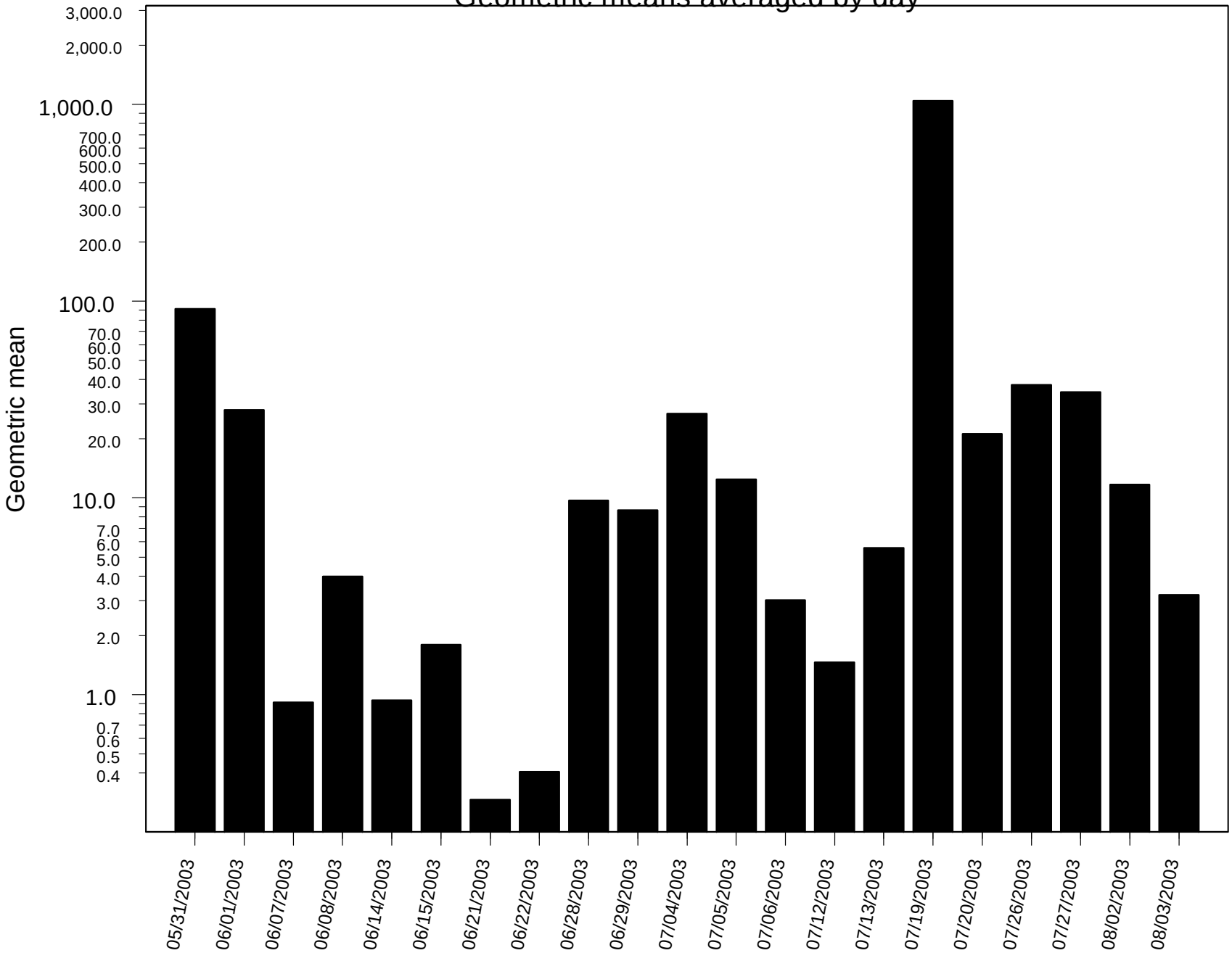
  N=336; mean=96; median=8; range=0/3,700
- **Enterococci QPCR**

  N=336; mean=599; median=127; range=0.03/15,778
- **Bacteroides QPCR**

  N=335; mean=10603; median=2105; range=16/234,408

Lake Michigan Enterococcus Method 1600

Geometric means averaged by day



Lake Erie Beach Water Quality

- **6 of 16 days (38%) exceeded current standards (33 cfu/100ml)**
- **Enterococci Method 1600**

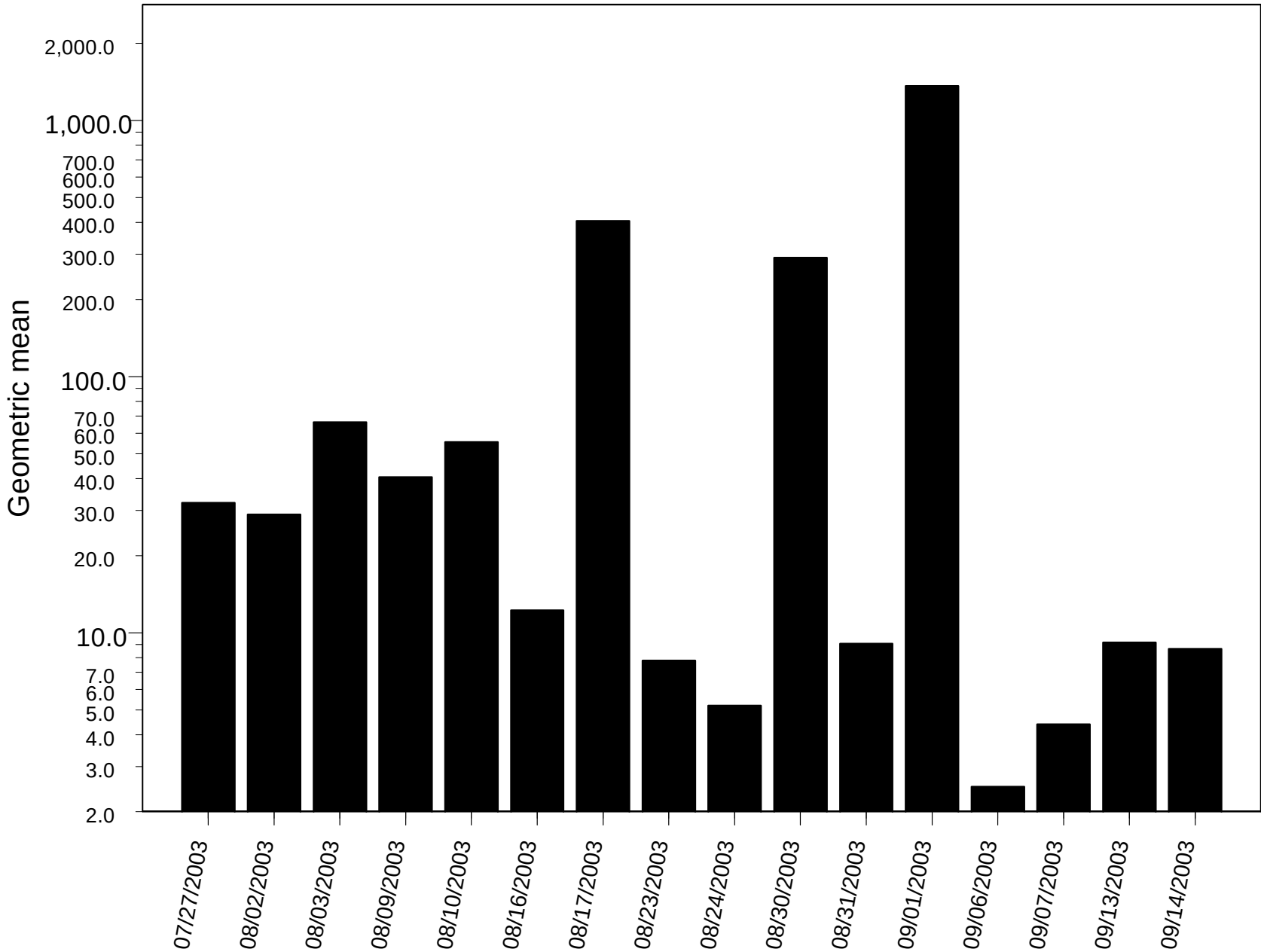
  N=420; mean=437; median=24; range=0/48,100
- **Enterococci QPCR**

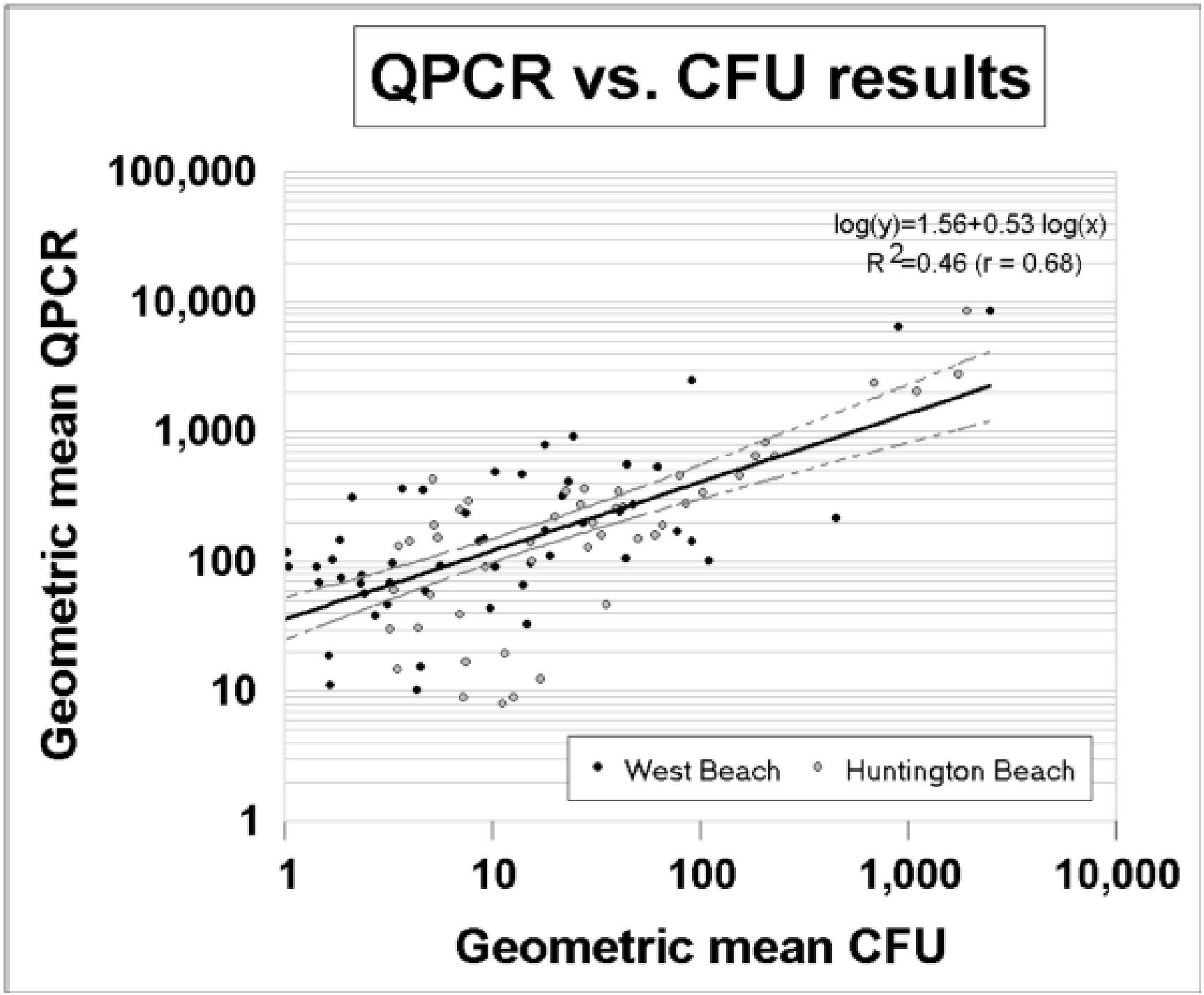
  N=418; mean=1119; median=168; range=0.02/114,286
- **Bacteroides QPCR**

  N=418; mean=11,360; median=5578; range=1/368,824

Lake Erie Enterococci Method 1600

Geometric means by day




QPCR vs. CFU results
log(y)=1.56+0.53 log(x)
R 2=0.46 (r = 0.68)
Geometric mean QPCR
100,000
10,000
1,000
100
10
1
West Beach
Huntington Beach
1
10
100
1,000
10,000
Geometric mean CFU

Survey Results: Swimming

	Lake Michigan	Lake Erie
Any contact	75%	46%
Body contact	58%	27%
Head under	42%	18%
Water in mouth	19%	12%
Gagged on water	6%	3%
Swallowed water	7%	4%
Wave riding	9%	5%

Lake Michigan:
Adjusted Odds Ratios for Swimming

	GI	URI	Eye	Rash	Earache
Any contact	2.22*	1.09	1.09	2.35*	1.40
Body contact	2.54*	1.06	1.19	2.44*	1.72
Head under	2.37*	1.09	1.25	2.42*	2.29*
*p<0.1					

Lake Erie:
Adjusted Odds Ratios for Swimming

	GI	URI	Eye	Rash	Earache
Any contact	1.43*	1.08	0.65	1.23	1.74
Body contact	1.62*	1.03	0.62	0.86	1.46
Head under	1.68*	1.11	0.51	1.00	1.36
*p<0.1					

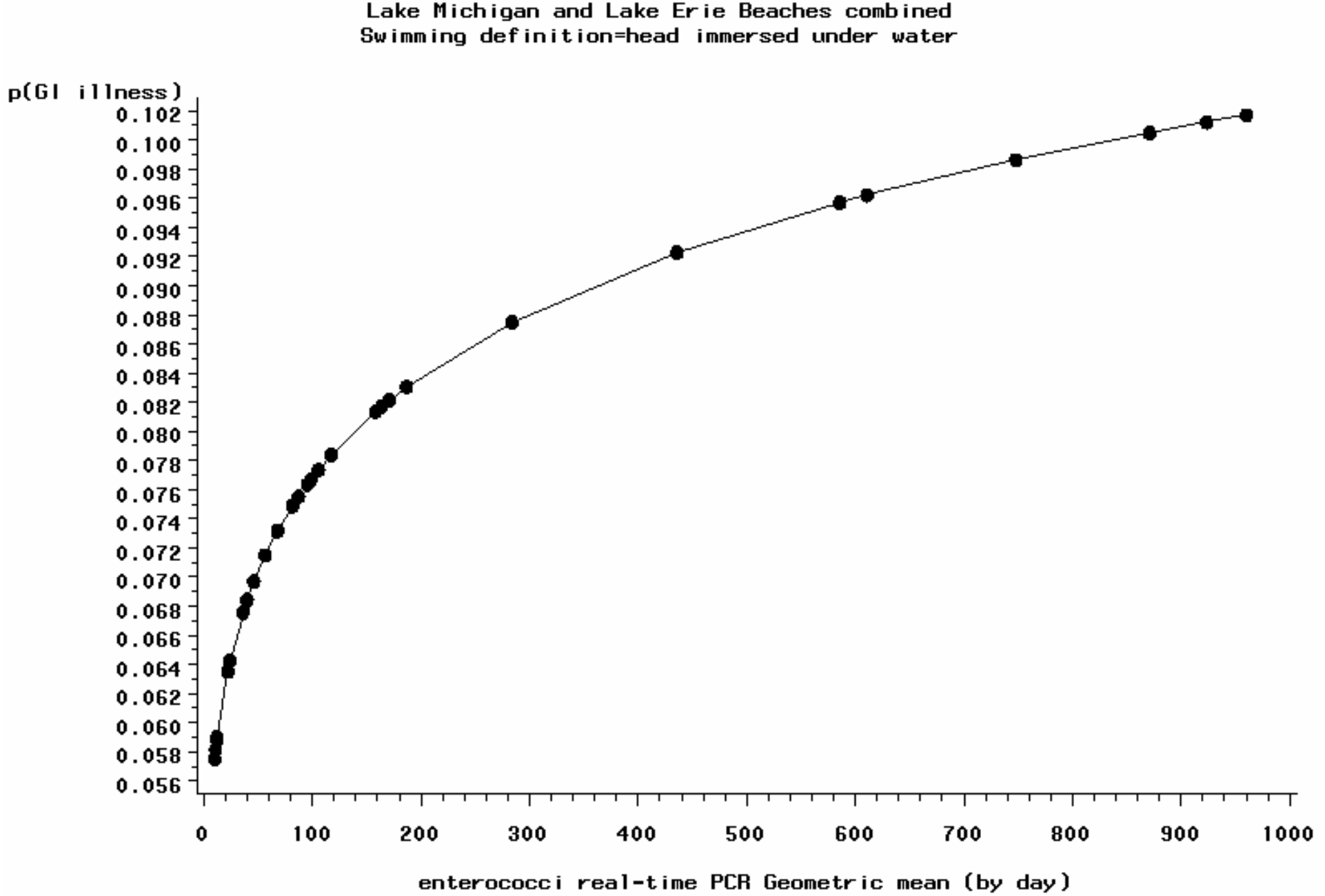
Lake Michigan: Trends for GI illness

	Enterococcus Method 1600		Enterococcus QPCR		Bacteroides QPCR	
	OR*	P-trend	OR**	P-trend	OR**	P-trend
Any contact	1.001	0.96	1.78	0.04	0.66	0.11
Body contact	1.07	0.63	1.94	0.04	0.64	0.12
Head under	0.96	0.82	2.15	0.03	0.58	0.12
	*30 unit increase		**100 unit increase		**500 unit increase	

Lake Erie: Trends for GI illness

	Enterococcus Method 1600		Enterococcus QPCR		Bacteroides QPCR	
	OR*	P-trend	OR**	P-trend	OR**	P-trend
Any contact	0.94	0.75	1.71	0.07	1.55	0.15
Body contact	1.36	0.28	2.06	0.07	1.95	0.08
Head under	0.92	0.82	1.51	0.37	2.10	0.09
	*30 unit increase		**100 unit increase		**500 unit increase	

Exposure response relationship between the probability of GI illness and enterococci measured by real time PCR



Probabilities predicted from multivariate logistic regression

Summary and Conclusions

- QPCR appears to be a promising predictor of gastrointestinal illness in fresh water
- Trends were not observed for respiratory illness
- Trends were not observed for rash, earache, and eye ailments, but more data may be necessary

Future Directions

- **Further evaluate and confirm fresh water results with two more beaches in 2004**
- **Better define risk to high risk groups such as children**
- **Evaluate other potential rapid indicators such as chemicals associated with sewage**
- **Studies in marine waters**